(12) UK Patent Application (19) GB (11) 2 293 222 (13) A

(43) Date of A Publication 20.03.1996

(21) Application No 9515031.4

(22) Date of Filing 21.07.1995

(30) Priority Data
(31) 9418707 (32) 16.09.1994 (33) GB

(51) INT CL[6]
F16L 11/11

(52) UK CL (Edition O)
F2P PM9 PR P1A19B P1A22 P1B7L P2A3 P2A5 P2C9A

(56) Documents Cited
GB 2126685 A GB 1543586 A GB 1294334 A
GB 0938049 A GB 0754219 A

(58) Field of Search
UK CL (Edition N) F2P PM9 PR
INT CL[6] F16L 11/11 11/112 11/115 11/118

(71) Applicant(s)
Stuart Grant Jones
Dacre Lea, Wetherby Road, Spofforth, HARROGATE, HG3 1BS, United Kingdom

Kenneth Neil John Jones
Dacre Lea, Wetherby Road, Spofforth, HARROGATE, HG3 1BS, United Kingdom

Ian Campbell Jones
Dacre Lea, Wetherby Road, Spofforth, HARROGATE, HG3 1BS, United Kingdom

(72) Inventor(s)
Stuart Grant Jones
Kenneth Neil John Jones
Ian Campbell Jones

(74) Agent and/or Address for Service
Dibb Lupton Broomhead
117 The Headrow, LEEDS, LS1 5JX, United Kingdom

(54) Convoluted plastics tube

(57) Apparatus for forming helical convolutions in thermoplastic tubes comprises a mandrel 7, 8 7a, tube heating means 1 designed to heat at least a portion of a tube placed over the said mandrel to a predetermined temperature which is sufficient to cause a chosen tube material to at least partially lose elastic memory, and a helical convolution forming element 6 which is operable to urge a tube into which the helical convolutions are to be formed against the said mandrel to form a helically convoluted tube. The mandrel 7, 8, 7a may be replaced by a second mandrel which allows a retaining element to be wound in place of the forming element 6 which has been removed.

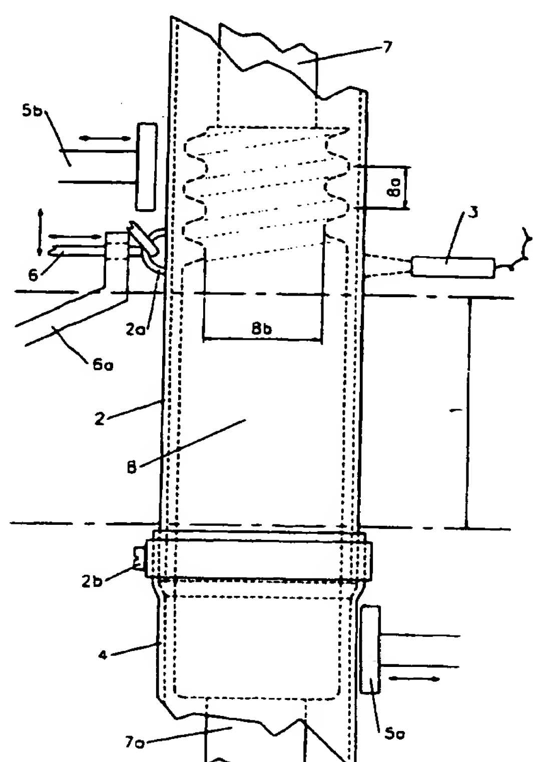

FIGURE 2.

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

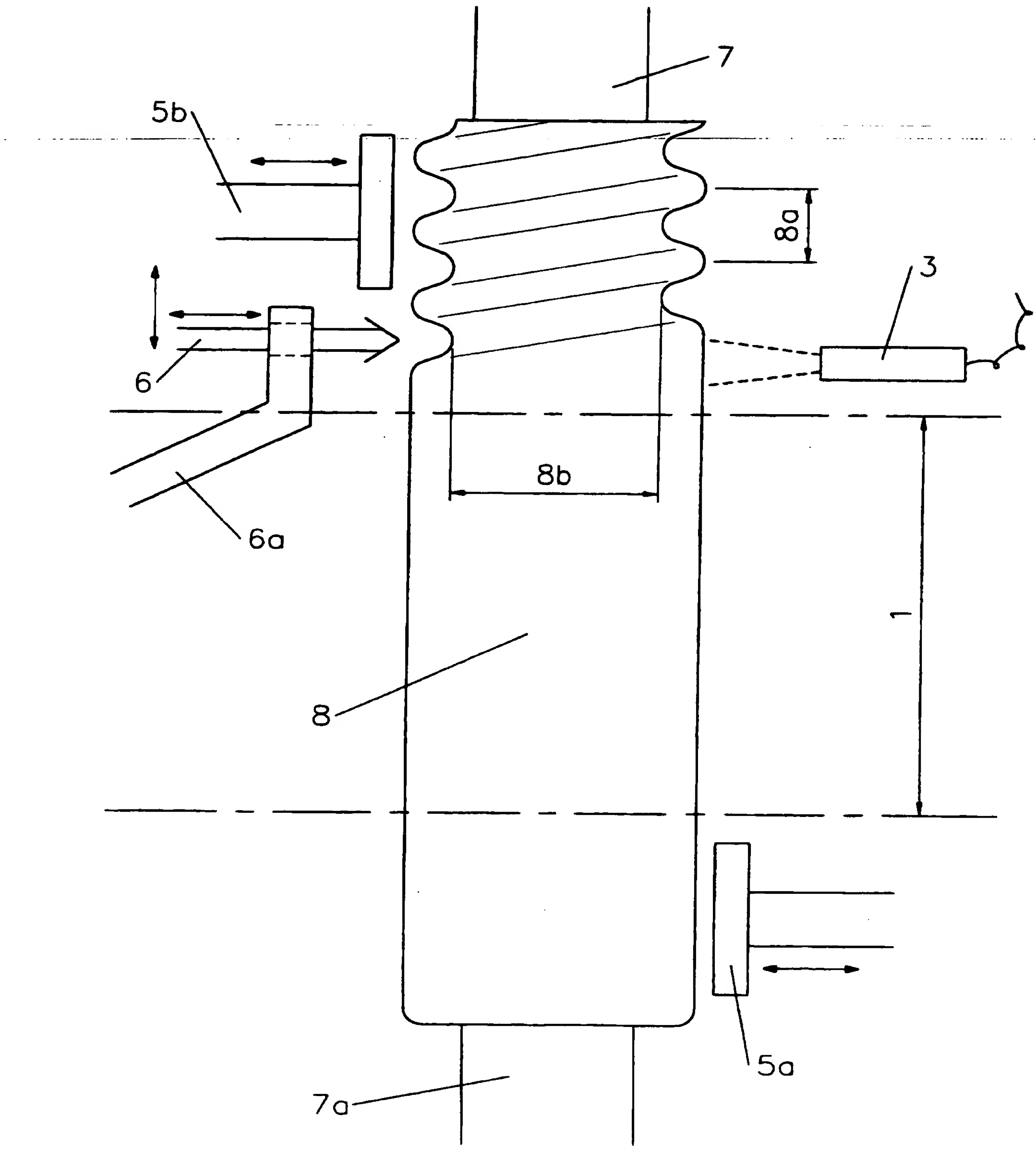

FIGURE 1.

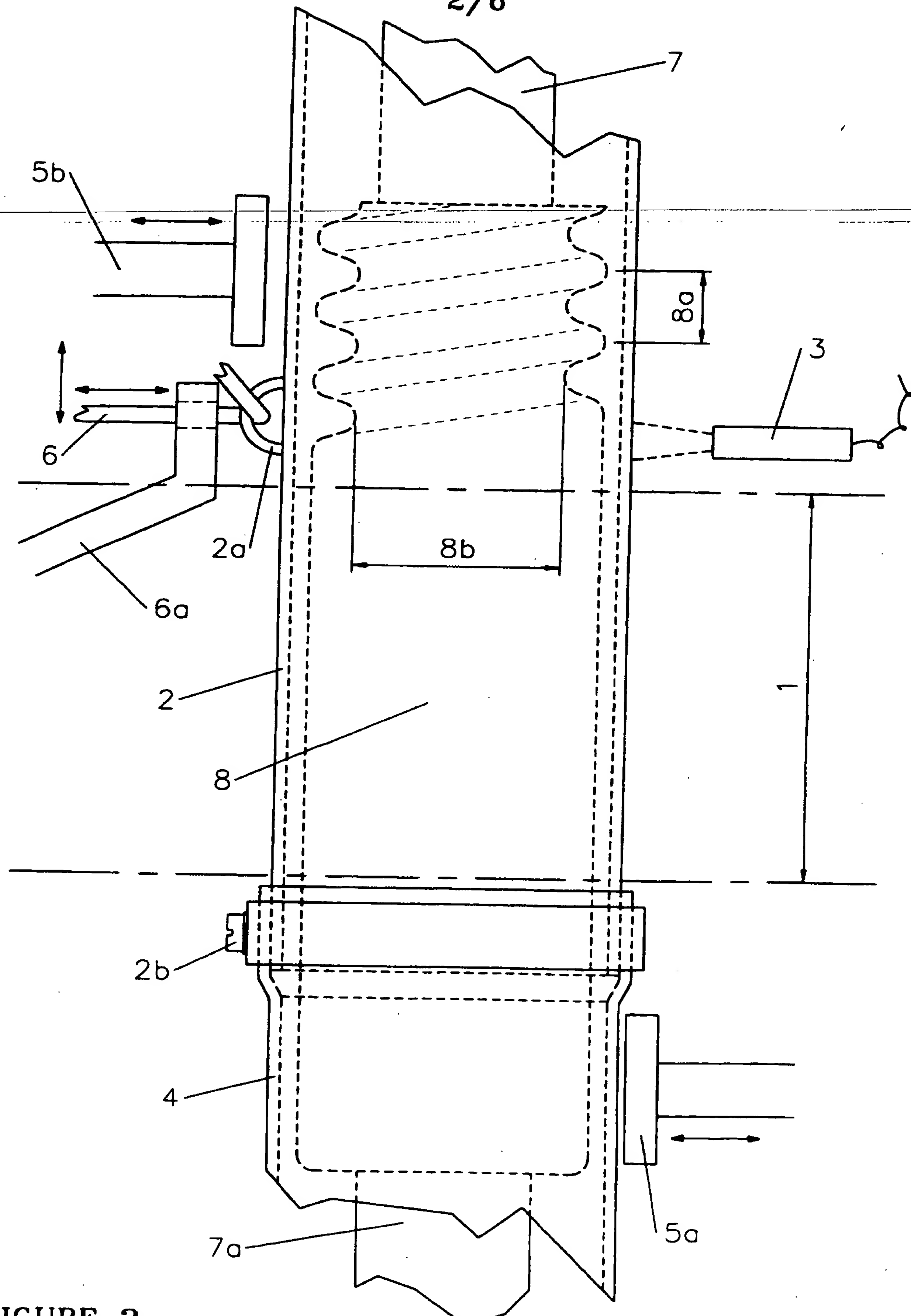

FIGURE 2.

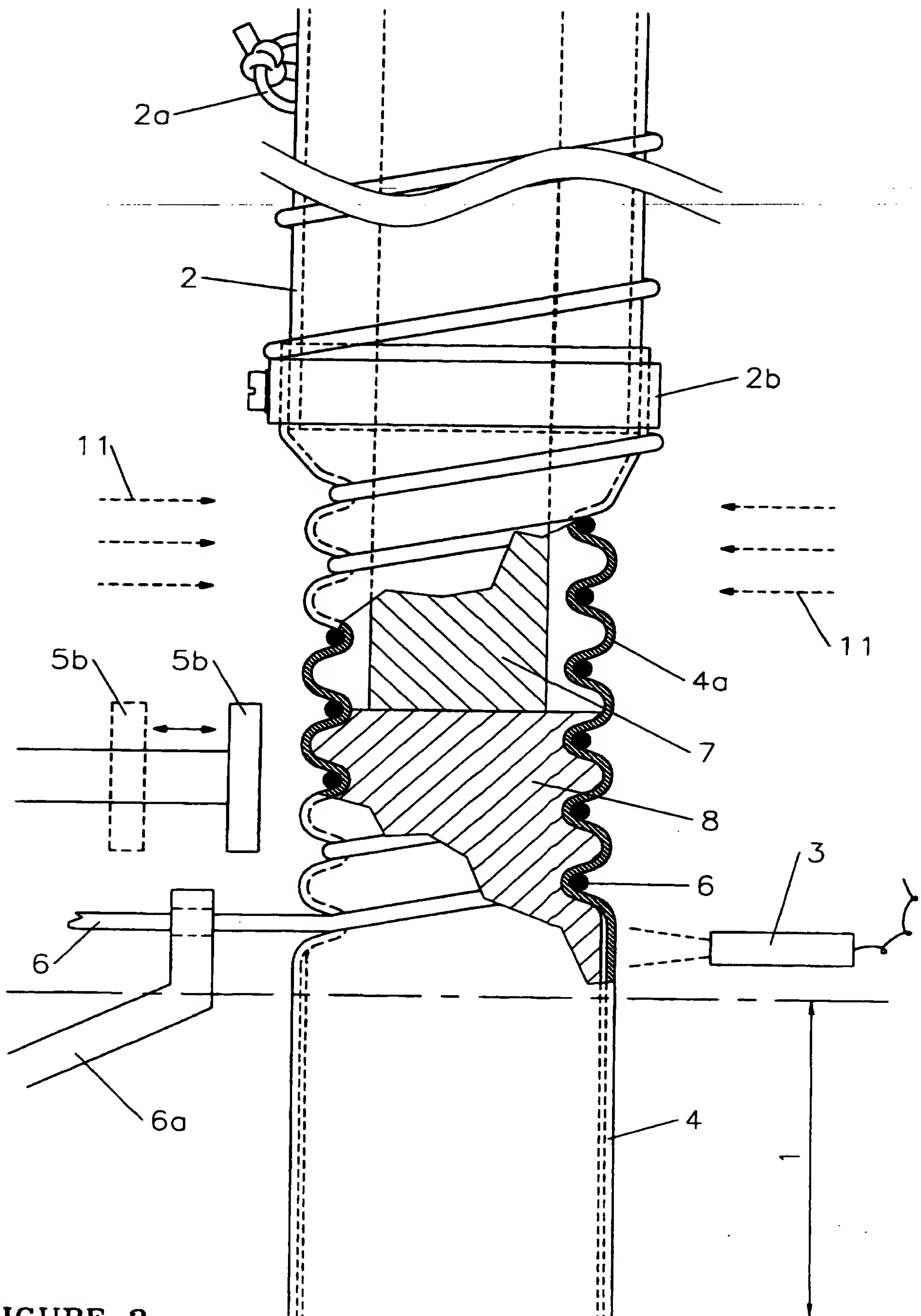

FIGURE 3.

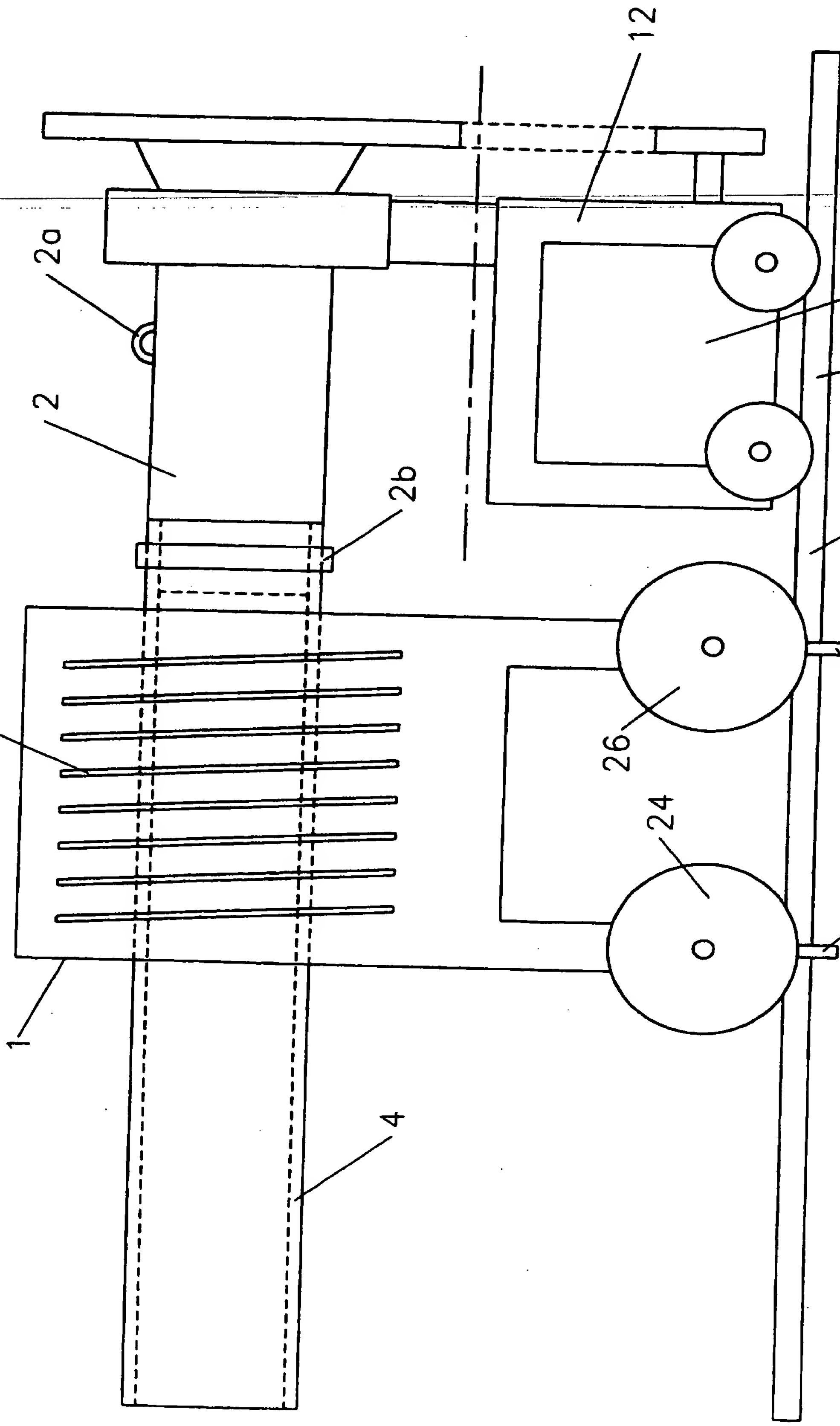

FIGURE 4.

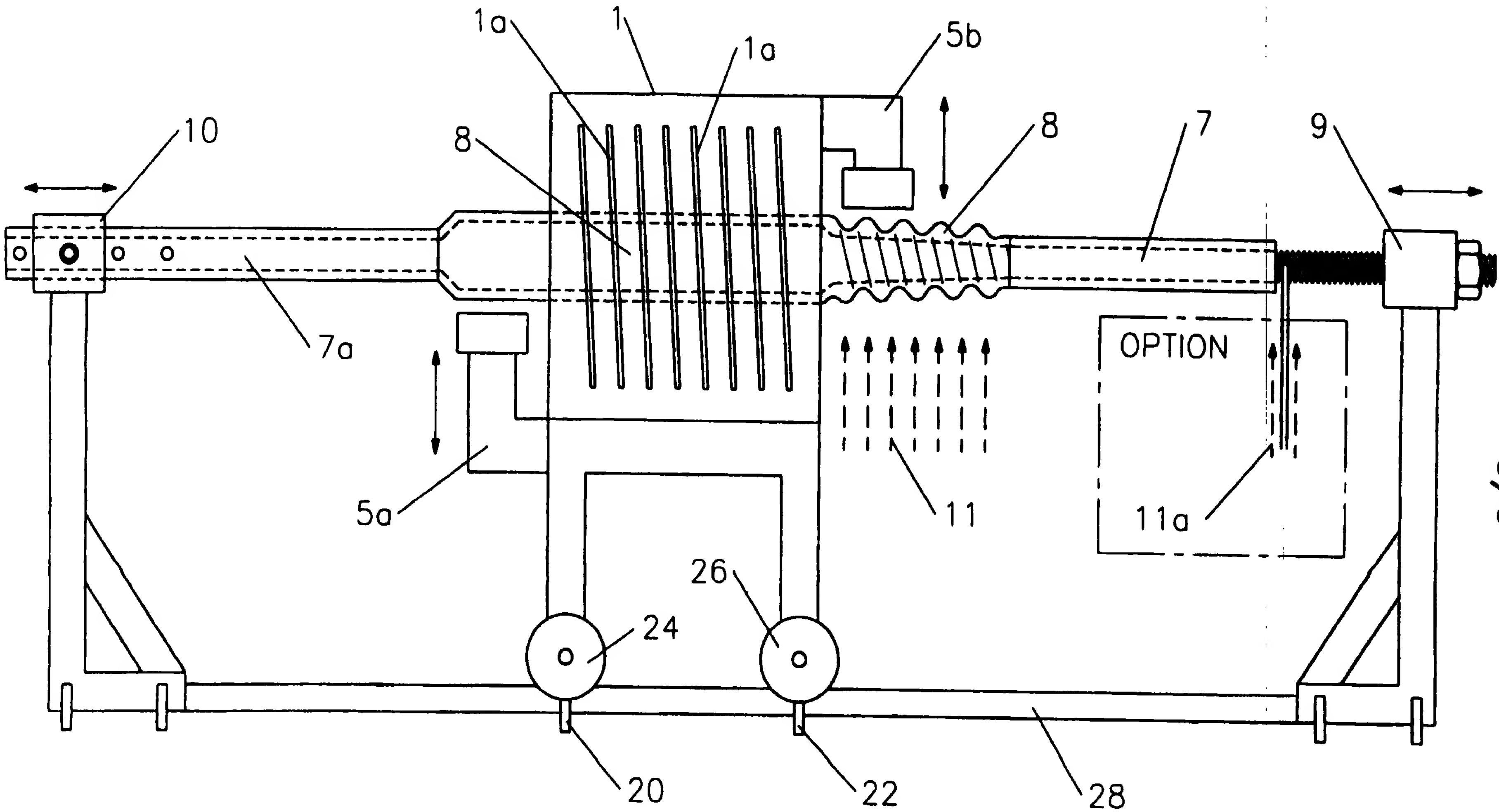

FIGURE 5.

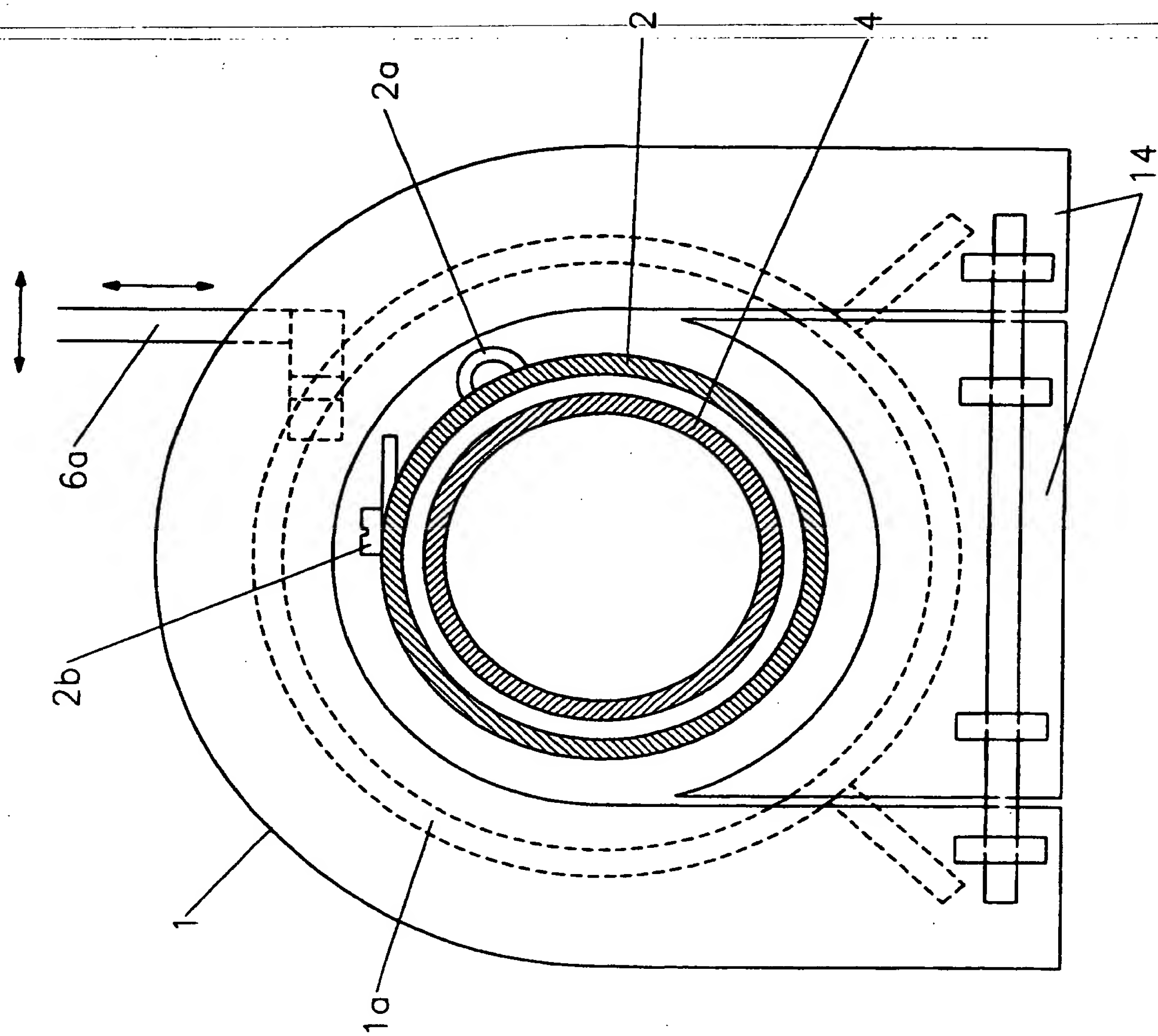

FIGURE 6.

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FORMING CONVOLUTED TUBES

This invention relates to a method and apparatus for forming convolutions in thermoplastic tubes.

In US patent specification 3327039, a method of producing spirally corrugated hoses which is fabricated of plastic material is described. Such a hose or tube is utilised where flexibility and elasticity are required in a tube having a relatively thick wall. The method generally describes use of a grooved mandrel over which a tube is placed to be forced into the grooves by a groove forming member. The method suffers from the drawback that certain stresses are built into the convoluted tube and the tube has a tendency to subsequently return to its original plain shape especially when used at high temperatures and high pressures. UK patent application number 2126685 discloses use of a heat setting step after the tube has been formed in order to remove the elastic memory from the tube so that it will not return to its original shape in use. UK patent number 1543586 discloses the use of a post formation heating step which softens the material to allow a spring which has been previously wound around the helical convolution to compress the convolutions into close configuration. The heating step also has the effect of heat setting the compressed convoluted tube. US patent number 4134958 discloses a post convolution heat treating step in order to relax the stresses set up in the tube and in order to retain the product in the shape given to it by the convolution forming process. The above methods all suffer from the drawback that the heat treating step needs to be carried out subsequently to the convolution forming step and thus the method of forming convoluted tubes involves a two step process.

It is an objective of the present invention to overcome these problems.

According to the present invention, there is provided apparatus for forming helically convoluted plastic tubes comprising a mandrel, tube heating means designed to heat at least a portion of a tube placed over the said mandrel to a predetermined temperature which is sufficient to cause a chosen tube material to at least partially lose elastic memory, and a helical convolution forming element which is operable to urge a tube into which the helical convolutions are to be formed against the said mandrel to form a helically convoluted tube.

Preferably, an infra red thermocouple monitors the temperature of the tube during helical convolution formation.

Advantageously, the invention provides a single continuous process producing stable stress free helically convoluted plastic tubes. The product is already heat set upon cooling and requires no further treatment in order to stabilise the product.

Preferably, the helical convolution forming element source, which is typically a reel of cable or wire, and the mandrel are fixed relative to each other and the tube rotates relative to the mandrel and the helical convolution forming element source to form the said helically convoluted tube.

In the preferred embodiment, the mandrel has a helically configured forming surface.

Typically, the tube heating means circumferentially surrounds a portion of the mandrel over which the tube is placed so that the tube may be heated over its whole circumference prior to helical convolution formation.

In use, the tube typically has one end fixedly located on a rotating sleeve which is aligned with the mandrel and adapted to move axially and rotatably away from the first mandrel at a rate that is suitable for forming said

helically convoluted tubes. When the helical convolution forming element is a cable or wire, the sleeve is first advanced over the mandrel. The cable or wire is then typically attached to the sleeve at a point which lies over the mandrel grooves which are located inside the sleeve. This takes place before tube formation but after the end of the tube has been heated (so that it expands) and slid on to the larger circumference of the end of the sleeve and secured thereon. Thus, in such apparatus, the sleeve may be rotated axially over and away from the mandrel and the cable or wire source bringing the tube behind it thus causing the cable or wire to wind around the sleeve and then the tube in a controlled manner in accordance with the speed of rotation of the sleeve and the rate of axial shift thereof. Typically, after being wound around the length of the sleeve (in a helical form) and the end of the tube which lies over the sleeve, the cable comes into contact with the free tube directly surrounding the helically configured forming surface of the mandrel and, due to the tension in the cable, the heated tube is forced into the helical groove in the mandrel and forms into a helically convoluted tube. Typically, the tube continues to rotate over the fixed mandrel and, in this manner, the desired length of helically convoluted tube with a cable retaining element wound around the helical grooves is formed.

Advantageously, as the helically formed heated tube moves away from the heater and the mandrel, the retaining element helps to maintain the shape of the tube as it cools.

Due to the heating process performed on the tube prior to or/and during convolution formation, the tube is already heat set upon cooling. Furthermore, the invention provides a single continuous process for forming heat set helically convoluted tubes.

In a preferred embodiment, the cable source and the mandrel are fixed with respect to each other and the rotating sleeve causes the tube to rotate over the mandrel

simultaneously drawing the cable from the cable source to form the helically convoluted tube. However, it is also envisaged that the mandrel may be axially movable and non-rotatable, axially movable and rotatable or rotatable and axially fixed.

A second sleeve to which the other end of the tube may be attached may also be rotated in cooperation with the first sleeve to prevent twisting of the tube and the two sleeves may also be axially relatively movable towards each other so as to take account of the natural compression in the tube during helical formation.

According to a second aspect of the present invention, there is provided a method of producing helically convoluted plastic tubes comprising the steps of locating a plain tube over a mandrel, heating at least a portion of the tube over the mandrel to a temperature which causes the tube material to at least partially lose its elastic memory and relatively engaging a convolution forming element and the heated tube to form helical convolutions in the said tube.

A preferred method maintains the temperature of the tube during helical convolution formation preferably at a pre-set figure within narrow limits.

Preferably, the forming element acts as a retaining element as the tube is formed and removed from the mandrel and this retaining element may be retained in the final product, removed from the final product, or removed and replaced by a further retaining element in the final product.

Thus, the convolutions are formed by the convolution forming element being pulled, preferably under constant pre-set tension, around the heated tube, and into the grooves of the internal helical mandrel, in a continuous process without the need for further heat setting.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 shows a view of a grooved helical mandrel and heater arrangement in accordance with the present invention;

Figure 2 shows the sleeve arrangement in accordance with the present invention;

Figure 3 shows the tube being formed in accordance with the present invention;

Figure 4 shows a buggy and heater arrangement in accordance with the present invention;

Figure 5 shows the apparatus with a tapered mandrel in accordance with the present invention; and

Figure 6 shows a sectional view of the heater in accordance with the present invention.

Referring to Figures 1 to 6, the present invention will now be described with reference to the accompanying drawings, numbered figs. 1-6.

The apparatus according to the invention comprises a mandrel 8 which has a helically grooved end fastened to a support mandrel 7, and a smooth end fastened to another support mandrel 7a. The mandrel 8 is partially supported by incoming bearings 5a. The O/D of the smooth end is uniform and is preferably approximately equal to the maximum O/D of the helically grooved end. The helically grooved end may be parallel (see figures 1, 2 and 3) or tapered (see figure 5) in profile. The mandrel may be entirely solid, partially hollow, or entirely hollow.

The pitch 8a of the helical groove on the mandrel is uniform along the entire length of the helically grooved

part of the mandrel 8, whether the mandrel is parallel or tapered. The minimum I/D of the helical groove in the mandrel 8b, when the helix profile is parallel or tapered is greater than the O/D of the support mandrel 7 to prevent friction between the mandrel 7 and the newly formed convoluted tube 4a.

The support mandrel 7 may be solid or hollow. It is fastened at one end to the mandrel 8 by a secure and non-rotatable quick release connection. The other end is externally threaded and is secured through a right hand fixed location 9 by means of suitable threaded nut. This provides axial adjustment for the mandrel 8.

The other support mandrel 7a has an O/D less than the O/D of the smooth part of the mandrel 8 to prevent friction between the support mandrel 7a and the plastic tube 4. It can be solid or hollow. It is fastened at one end to the mandrel 8 by a secure and non-rotatable quick release connection. Close to its other end a number of holes have been drilled through it. They each ensure secure non-rotatable connection with a left hand fixed location 10 whilst providing axial adjustment for the mandrel 8.

One end of the right hand fixed location 9 is securely mounted to the floor by suitable means. At the other it provides a means of locating the support mandrel 7 and providing fine axial adjustment of the mandrel 8. The left hand fixed location 10 is similar. At one end it is securely mounted to the floor by suitable means. At the other end it provides a means of locating the support mandrel 7a and providing coarse axial adjustment of the mandrel 8.

The connections formed by the support mandrel 7a and the left hand fixed location 10, and the support mandrel 7 and the right hand fixing location 9, ensure that the axis formed by the mandrels 7a, 8 and 7 is horizontal.

The incoming bearings 5a are vertically adjustable to ensure that different sizes of tubing 4 are guided centrally through the heater 1. They also partially support the mandrels 7, 7a and 8, and allow the plastics tubing 4 to rotate and move axially as required. The outgoing bearings 5b can be held in an upper position as required during some stages of the process; but they are secured in a lower position to hold the mandrel 8 and convoluted plastics tubing 4a in a stable horizontal position, whilst acting against the tension provided by the convolution retaining element 6 when the process is operating automatically.

A heater 1 is located horizontally and is height adjustable to ensure the sleeve 2 can pass freely through its centre. It can be moved to the left hand side if necessary to make it easier to remove the mandrel 8 and replace it with another mandrel. In such embodiments, the incoming bearings can also be moved to the left hand side or be removed from the path of the heater to accommodate movement of the heater. The heater is moved by releasing wheel locks 20,22 and rolling the heater on its wheels 24,26 along track 28. Removable heater doors can be mounted at each end of the heater 1 as it heats the plastics tubing 4 passing through. They can be removed manually if needed. The sleeve 2 is able to rotate and move axially in either direction, and at predetermined speeds. Either movement can occur on its own or they can occur together. When then they occur simultaneously these rules are observed:

(a) for each complete 360° rotation, the axial movement is approximately equal to the pitch of the helical part of the mandrel 8a;

(b) anti-clockwise rotation when viewed from the right hand side ensures axial movement from left to right (and vice-versa).

The internal diameter of the sleeve (2) is greater than the maximum outside diameter of the mandrel (8), and the support mandrels (7) and (7a), so it is able to move axially along, or/and rotate around them without friction or contact.

The heater elements (1a) are linked via a heater control system to an IR thermocouple (3). The heating elements (1a) are typically infra-red elements and their wavelengths are chosen to best suit the material being heated. Long wave infra-red elements may for example be used to heat P.T.F.E. tube. The infra-red thermocouple (3) is positioned with respect to the plastics tube (4) such that it can "see" nothing else within its field of view. The infra-red thermocouple (3) is calibrated to ensure its readings are in °C/°F.

The heater control system ensures that once the heated but still non-convoluted plastics tube (4) has come within the view of the IR t/c (3), its surface temperature (4) is kept (within very narrow limits) at a constant predetermined figure, at about the same time that the convolution retaining element (6) is wrapped around it.

A sleeve-clip (2b) secures plastics tubing (4) to the sleeve (2). An eye (2a) is securely attached to the sleeve (2) at a distance about equal to the length of the heater (1) from the sleeve-clip (2b).

Another eye (6a) is securely fastened to the floor and the position of the eye is adjustable in all directions, to ensure that a convolution retaining element (6) is properly guided onto the plastics tubing (4) and pulled into the correct convolution on the helical part of the mandrel (8). The convolution retaining element (6) is pulled through the "eye" (6a) and securely attached to the eye on the sleeve (2a). It is then wrapped along the sleeve (2) and onto the plastics tubing (4), in a helical form supported by the

helical part of the mandrel (8) to create the convoluted plastics tubing (4a).

The incoming non-convoluted plastics tubing (4) is supported by the incoming bearings (5a) which also allow it to rotate and move axially as required. The outgoing convoluted plastics tubing (4a) is formed against the helical mandrel (8) when the Convolution retaining element (6) is wrapped around the plastics tubing (4) under constant pre-set tension. The tension may be adjusted to suit different tube materials, size and wall thickness etc.

For external compressed-air tube cooling (11), Compressed air at a predetermined pressure can be released around the newly convoluted plastics tubing (4a), at about the time (or shortly after) the convolution retaining element (6) is wrapped around it. Nozzles can be positioned at different points around the convoluted tubing (4a) to ensure 360° cooling. Immediate cooling increases axial rigidity of the newly convoluted tube (4a) and helps to fix its convolutions into position more quickly.

OPTIONS

An Internal compressed air, or liquid cooling system (11a) may be used together with external cooling system (11) or on its own. Its purpose is to cool the convoluted tubing (4a) as quickly as possible. However, this also has the advantageous effect of keeping the mandrel cool. The system forces either compressed air or liquid down the inside of a hollow support mandrel (7) from the right hand fixed location (9) towards the mandrel (8). The mandrel (8) will be hollow for liquid cooling, but only partially hollow for compressed air. Where air is used, small holes drilled through the bottom of the helical grooves into the hollow part, allow it to reach outer surface of helical groove and the inner surface of newly convoluted tubing (4a). This helps to fix convolutions into position more quickly and also helps reduce friction between the mandrel

(8) and the convoluted tube (4a). It is preferable not to have these small holes when using liquid cooling - but instead the liquid passes through the mandrel (8) and out of support mandrel (7a) at the other end of mandrel (8). If necessary it can be pumped back through support mandrel (7) locked at the other end of mandrel (8) creating a closed system.

It is realised that in some cases it may be preferable to provide suitable lubrication to the external part of the helical mandrel prior to operating the process to help reduce the friction generated between the external surface of said mandrel and the internal surfaces of the tube and the newly convoluted tube. This may be combined with internal liquid or gas cooling as well as external gas cooling.

A suitable motor drive layout will now be described. A buggy (12) is attached and fixed to the sleeve (2) by suitable bearings. The sleeve (2) can be rotated by means of the motor-drive (15) which is mounted inside the buggy (12). The buggy (12) moves on suitable rails (13). The buggy (12) may, again, be made to move by the motor-drive (15).

Before the process is begun, the following items are checked:

that the sleeve size is correct and the sleeve is able to pass clearly through the centre of the heater (1);

that the following specifications of the convolution retaining element (6) are correct:

(i) O/D	(iii) flexibility
(ii) material	(iv) pre-set tension;

that the axial movement of the sleeve (2) with respect to direction of sleeve rotation is correct.

that the pre-determined axial and angular velocities of sleeve (2) are correctly stored within the motor-drive system;

that the parameters stored within the heater control system are correct;

that the incoming bearings (5a) are set at the correct height to centre the plastics tubing (4) as it passes through the heater (1);

that the eye (6a) is correctly adjusted to locate the convolution retaining element (6) into the correct convolution groove, and that it is securely fastened;

that each of the heater doors (14) are the correct size and fit properly;

that the heater settings and associated time delays (for the first part of the process before the automatic heater control system takes over) are correct and readily available;

that the IR t/c (3) is connected to the heater control system and is correctly calibrated with respect to the type of material to be convoluted; and

that the compressed air cooling system (11a) and/or other cooling systems, (11b) is/are connected up ready for use, and set at the correct pressure(s).

The process is carried out as follows. Firstly, the connections between mandrels (7a), (8) and (7) are non-rotatably secured. Next the connection between support mandrel (7a) and left hand fixed location (10) is unfastened and the plastics tubing (4) is slid onto the support mandrel (7a). The support mandrel (7a) and fixed location (10) are then reconnected securely and non-rotatably.

The mandrel (8) is lined up as shown in fig. 1. Axial adjustment is provided by fixed positions (9) and (10). The outgoing bearings (5b) are slid into their upper position as shown in figure 3.

The sleeve (2) is positioned a short distance to the right hand side of the outgoing bearings (5b).

The right hand end of plastics tubing (4) is pushed a short distance inside the left hand side of the heater (1). The heater elements (1a) are turned on and heat the end of the plastics tubing (4) until it gets hot and its internal diameter expands. Immediately the plastics tubing (4) is large enough to slide onto the sleeve (2) the heater element (1a) is turned off.

The plastics tubing (4) is pushed further through the heater (1) towards the right hand side until the hot expanded end is very close to the sleeve (2). It is then carefully slid onto the sleeve (2) and secured it by means of the clip 2b. The sleeve (2) and attached plastics tubing (4) are then pushed towards the left hand fixed location (10), until sleeve (2), eye (2a) and clip (2b) are in the position shown in figure 2. The convolution retaining element (6) is pulled through the eye (6a) and securely fastened to the eye (2a).

The heater doors (14) may then be placed at each end of the heater (1) as shown in figure 6. The IR t/c (3) is put in place and connected to the heater control system such that its entire field of view is filled by plastics tubing (4). See figure 3.

The heater elements (1a) are set according to predetermined parameters and turned on. After a predetermined period the sleeve (2) is engaged for anticlockwise rotation when viewed from the right hand side; and axial movement from left hand side to right hand side.

The convolution retaining element (6) is steadily wrapped around and along the sleeve (2) with a pitch approximately equal to that of the helical part of the mandrel (8). The convolution retaining element (6) will then cross the clip (2b) and be guided onto the plastics tube (4) by the eye (6a). See figure 3.

As soon as the rotating sleeve (2) has moved far enough to the right hand side, the outgoing bearings (5b) are dropped onto the newly convoluted tubing (4a) as shown in figure 3. The compressed air and liquid cooling systems (11) and (11a) may be engaged as required at predetermined pressure(s). See figure 5.

The process now operates automatically since the IR t/c (3) now sees the hot plastics tubing (4) as the convolution retaining element (6) is wrapped around it, and ensures with the aid of the heater control system, that the heater elements (1a) keep its surface temperature constant (within acceptable limits) at a pre-set figure.

The pre-set parameters chosen for the heater elements and the associated time delays ensure that the initial temperature readings of the tube (4) made by the infra-red thermocouple (3) are about equal to the pre-set process temperature.

Immediately the convolution retaining element (6) has wrapped itself all the way along the plastics tubing (4), The heater elements (1a) should be turned off and both axial and rotational movements of the sleeve (2) disengaged. The tubing (4a) may be allowed time to cool. The Convolution retaining element (6) is cut below the eye (6a) using suitable clips.

Generally the convolution creating element 6 will be retained on the convoluted tube 4a, in order that it can be made into a commercially acceptable hose or flexible conduit. However, in some cases, it may be preferable to

remove it from the convoluted tube 4a. The method described as follows shows how this invention can perform this task in a few simple steps. The process is performed as previously described up to the point where the convoluted tube 4a is left to cool. But instead of cutting through the convolution creating element 6, a suitable length of it is pulled through from its source (usually a suitable reel) creating "slack". Previous steps are again followed until the convoluted tube 4a is a sufficient distance onto the support mandrel 7, so that it and the helical mandrel 8 can be disconnected. The helical mandrel 8 is removed from support mandrels 7 and 7a and replaced by a uniform smooth mandrel (not shown). Preferably, the heater 1 and incoming bearings 5a are able to be slid, wheeled or moved to the left hand side to make the removal of the mandrel 8 easier. Subsequent vertical height adjustment of the bearing 5a may be necessary to centre the smooth mandrel. The length of the smooth mandrel is generally approximately equal to the helical mandrel 8. The "slack" prevents the convolution creating element 6 wrapping around the helical grooves of mandrel 8, prior to its removal.

The uniform smooth mandrel has an overall diameter less than the minimum internal diameter 8b of the original mandrel and also less than the internal diameter of the cool convoluted tube 4a to prevent unnecessary friction. The sleeve 2 will now run in reverse (from RHS to LHS and clockwise when viewed from RHS). Axial movement of sleeve 2 is now proportional to the pitch of the convoluted tube 4a. The element 6 is removed from the convoluted tube 4a, then the sleeve 2 under pre-set tension. It is preferably collected by suitable means such as a motor-driven rotating reel. Drive is then disengaged. The element 6, then the tube is removed from the sleeve 2. Connection between mandrel 7a and the uniform smooth mandrel is broken, and the tube 4a is removed from the mandrel 7a. No heat is used to perform this task.

It is also realised that there will be cases where it is preferable once the original convolution creating element 6 has been removed from the convoluted tube 4a as described above, to apply another such element to it. This is performed as follows:

Previous steps are followed until the original element 6 has been removed from the sleeve 2. A suitable new element is secured to 2. It is then driven from LHS to RHS (with anti-clockwise rotation as viewed from RHS). Axial movement is proportional to the pitch of 4a. The new element is pulled under tension into the convolutions created by the original element 6.

When the "wrapping" is finished, the convoluted tube 4a is removed as before. No heat is used to perform this task.

The outgoing bearings 5b are then pushed into their upper position as shown in figure 3. The compressed air and liquid cooling systems (11) and (11a) are disengaged.

Axial and rotational drive to the sleeve (2) is then engaged in the same direction as before to "screw" the convoluted plastics tubing (4a) from the helical part of the mandrel (8) and onto (7). This axial and rotational drive is then disengaged.

The plastics tube (4a) can then be released from the sleeve (2) by unfastening the clip (2b); removing the convolution retaining element (6) from the eye (2a); making an axial cut right through and along the short length of plastics tubing (4) which has been pushed onto the sleeve (2); and gently pulling the plastics tubing (4) and sleeve (2) apart. It may also be necessary to cut through the convolution retaining element (6) close to the clip (2b) before pulling the tube (4) and the sleeve (2) apart.

Any tension exerted on mandrels (7), (7a) and (8) can be released by loosening the connection at (9). The support

mandrel (7) is unfastened from the mandrel (8) and the entire length of the convoluted plastics tubing (4a) can be slid from the support mandrel (7).

Once the mandrels (7) and (8) are fastened together again, the apparatus and process are is ready for reuse.

Various modifications and alterations to the invention are possible, in particular, the relative manner in which the forming element, the mandrel and the sleeve rotate and move axially with respect to each other can have a number of possible permutations without detracting from the invention as described. In addition, the heater may be movable axially along the mandrel both for precision positioning thereof and also as an alternative method of convolution formation where the heater moves along with the forming element and the mandrel, while the tube remains axially fixed.

In an alternative embodiment, in order that the angular velocities of the tube and the newly convoluted tube are kept equal, it may be preferable to have both ends of the tube (convoluted and plain) driven simultaneously at the same velocity. Although it has been found that the angular velocities of both convoluted and unconvoluted tube can usually be kept equal (within acceptable limits) by driving the convoluted end only. Where both ends are driven together axial adjustment is required to allow for the compression of the tube's length which occurs due to the convoluting process.

It is realised that in some cases it may be preferable to provide suitable lubrication to the external part of the helical mandrel prior to operating the process to help reduce the friction generated between the external face of said mandrel and the internal surfaces of the tube and newly convoluted tube.

It is realised that lubrication may be combined with internal or/and external gas cooling; that lubrication may be combined with internal liquid cooling (with or without external gas cooling); that external gas cooling may be combined with internal liquid cooling, but that internal gas cooling and internal liquid cooling may not be appropriate together.

It is realised that in order to further increase the axial and torsional rigidity of the newly formed convoluted tube (by helping to 'fix' the convolutions into place more quickly), or/and further reduce the friction between the helical mandrel and the tube, it may be preferable to cool the newly formed convoluted tube using suitable gas-cooling, this being 'applied' internally or/and externally (at pre-set pressure) as required. External gas cooling (eg compressed air) will usually be applied to the tube as or/and shortly after the convolution creating element has been applied. A partially hollow helical mandrel which has many small holes drilled between its external helically grooved surface and its hollow interior can provide internal gas cooling to the tube (as well as reducing friction between tube and said mandrel), via a hollow support mandrel.

In some cases it may be necessary to keep the mandrel itself cool during the process, by means of internal liquid cooling. All mandrels will be hollow with the liquid flow from one support mandrel, through the helical mandrel (which in this case would not usually have any holes between its interior and external helical face), and out of the other support mandrel.

The tubes from which the hoses produced in the process are formed are of flexible material, preferably a plastics or thermo-plastics material, such as P.T.F.E..

The internal diameter of the tube is generally a little larger than the maximum overall diameter of the helical

mandrel, to prevent unnecessary friction between them. When necessary, the tube is made to rotate and move axially by a rigid sleeve (or similar) to which it is securely attached. Where both ends are driven, a sleeve is attached at each end, and both are made to rotate together, with suitable axial adjustment.

The internal diameter of the cold tube is a little less than the overall diameter of said sleeve. Heating the end of said tube causes it to soften and its internal diameter to expand sufficiently such that it can be 'slid' onto said sleeve, where (after cooling and contracting) it is secured by suitable means.

The internal diameter of the cold convoluted tube is a little larger than the overall diameters of the support mandrels to prevent unnecessary friction between them.

The convolution creating element used in accordance with this invention may be composed of any suitable material strong enough to achieve the particular tension desired for optimum convolution, whilst being able to withstand the surface temperature of the newly convoluted tube, without prejudice to its performance or its physical or/and chemical composition. In addition, it must be small enough to fit into the convolutions of the mandrel together with the tubing. It may for example comprise a metal wire. Once in place wrapped around a convoluted tube, it may then be regarded as a convolution reinforcing element. Convolution creating/reinforcing elements (with suitable flexibility) of various types and materials may thus be used, selected from a wide range of cross-sectional area, to offer enhanced support to the convoluted tube to improve pressure bearing or reduce fatigue, or to stand proud of the crests of the convolutions so as to keep any externally applied braiding or other covering material from chafing the convoluted tube.

For specific applications the convolution creating element may be small diameter hollow tubing (braided or unbraided) which would be used to carry a heating or cooling medium around the helical convolutions through the small tubing so that when made into an assembly complete with appropriate fittings the medium being transferred through the tubing can be kept at a constant temperature.

Claims

1. Apparatus for forming helically convoluted plastic tubes comprising a mandrel, tube heating means designed to heat at least a portion of a tube placed over the said mandrel to a predetermined temperature which is sufficient to cause a chosen tube material to at least partially lose elastic memory, and a helical convolution forming element which is operable to urge a tube into which the helical convolutions are to be formed against the said mandrel to form a helically convoluted tube.

2. Apparatus for forming helically convoluted plastic tubes comprising a mandrel and a helical convolution forming element which is operable to urge a tube into which the helical convolutions are to be formed against the said mandrel to form a helically convoluted tube, wherein the apparatus includes a second mandrel, to replace the first mandrel after helical convolution formation, which allows the tube to be rotated thereover and a retaining element which is wound into the said helical formations during rotation of the tube over the said second mandrel.

3. Apparatus as claimed in any preceding claim, wherein a thermocouple monitors the temperature of the tube during helical convolution formation.

4. Apparatus as claimed in any preceding claim, wherein the helical convolution forming element source and the mandrel are fixed relative to each other and the tube rotates relative to the mandrel and the helical convolution forming element source to form said helically convoluted tube.

5. Apparatus as claimed in any preceding claim, wherein the mandrel has a helically configured forming surface.

6. Apparatus as claimed in any preceding claim, wherein the tube heating means circumferentially surrounds a portion of the tube during formation.

7. Apparatus as claimed in any preceding claim, wherein, in use, the tube has one end fixedly located on a sleeve which is adapted to move axially away from the first mandrel at a rate suitable for forming said helically convoluted tube.

8. Apparatus as claimed in any preceding claim, wherein the said forming element is a cable or wire which, in use, is wound around the tube to form and at least partially retain said helical convolutions.

9. Apparatus as claimed in any preceding claim, wherein one end of the wire or cable is fixed to the sleeve and the cable source is fixed with respect to the first mandrel.

10. Apparatus as claimed in any preceding claim, wherein the mandrel is axially fixed and non-rotatable.

11. Apparatus as claimed in any of claims 1 to 2 or 4 to 9, wherein the first mandrel is axially movable and non-rotatable.

12. Apparatus as claimed in any of claims 1 to 2 or 4 to 10, wherein the first mandrel is rotatable.

13. Apparatus as claimed in claim 12, wherein the mandrel is axially movable.

14. Apparatus according to claim 8 when appendant to claim 2, wherein means are provided to unwind the cable or wire after mandrel replacement.

15. Apparatus according to claim 14, which includes a retaining element operable to be wound into the helical grooves after removal of the said forming element.

16. Apparatus according to any preceding claim, wherein means are provided to rotate the sleeve and tube both axially away from and towards the said forming element source to effect helical winding and unwinding of the said forming element.

17. A method of producing helically convoluted plastic tubes comprising the steps of locating a plain tube over a mandrel, heating at least a portion of the tube over the mandrel to a temperature which causes the tube material to at least partially lose its elastic memory and relatively engaging a convolution forming element and the heated tube to form helical convolutions in the said tube.

18. A method as claimed in claim 17, wherein a thermocouple monitors the temperature of the tube during helical convolution formation.

19. A method as claimed in claims 17 or 18, which includes the step of rotating the tube relative to a fixed mandrel and a fixed helical convolution forming element source to form said helically convoluted tube.

20. A method as claimed in any of claims 17 to 19, wherein the tube heating means circumferentially surrounds a portion of the tube during formation.

21. A method as claimed in any of claims 17 to 20, which includes the step of lubricating the tube with a lubricant prior to or during helical formation.

22. A method as claimed in any of claims 17 to 21, which includes the step of fixedly locating the first end of the tube to be formed on a rotatable sleeve.

23. A method as claimed in any of claims 17 to 22, which includes the step of rotatably moving the sleeve axially away from the first mandrel at a rate suitable for forming said helically convoluted tube.

24. A method as claimed in any of claims 17 to 23, which includes the steps of fixing a wire or cable forming element to the sleeve, rotating the sleeve at a rate suitable for forming said helical convolutions with said wire or cable as the tube rotates with respect to the wire or cable source.

25. A method as claimed in any of claims 17 to 24, which includes the step of removing the wire or cable forming element after formation of the completed tube.

26. A method as claimed in claim 25, which includes the step of helically winding a new retaining element into the helical grooves in the tube after removal of the forming element.

27. A method as claimed in any of claims above 17-26 where tube is driven by cooperating sleeves located at both ends thereof.

28. A method as claimed in claim 27, which includes axially relatively moving the two said sleeves to take account of compression of the tube after helical formation.

29. A method as claimed in claim 25 which is carried out without removing the tube from the sleeve by rotating the said sleeve back towards the forming element source to unwind the said forming element.

30. A method as claimed in claims 26 or 29 which is carried out without removing the tube from the sleeve by rotating the said sleeve away from a retaining element source after the steps of replacing the forming element source with a retaining element source and securing the retaining element to the sleeve.

31. Apparatus for forming helically convoluted plastic tubes as hereinbefore described and with reference to Figures 1, 2 and 3.

32. Apparatus for forming helically convoluted plastic tubes as hereinbefore described and with reference to Figure 4.

33. Apparatus for forming helically convoluted plastic tubes as hereinbefore described and with reference to Figure 5.

34. Apparatus for forming helically convoluted plastic tubes as hereinbefore described and with reference to Figure 6.

35. A method of forming helically convoluted tubes as hereinbefore described and with reference to Figures 1 to 3.

36. A method of forming helically convoluted tubes as hereinbefore described and with reference to Figure 4.

37. A method of forming helically convoluted tubes as hereinbefore described and with reference to Figure 5.

38. A method of forming helically convoluted tubes as hereinbefore described and with reference to Figure 6.

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Patents Act 1977
Examiner's report to the Comptroller under Section 17
.'he Search report)

Application number
GB 9515031.4

Relevant Technical Fields

(i) UK Cl (Ed.N) F2P (PM9, PR)

(ii) Int Cl (Ed.6) F16L 11/11, 11/112, 11/115, 11/118

Search Examiner
R F PHAROAH

Date of completion of Search
24 AUGUST 1995

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii)

Documents considered relevant following a search in respect of Claims :-
1, 3-13, 16-38

Categories of documents

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Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2126685 A	(STANDARD HOSE) see page 1, lines 65, 66	1
X	GB 1543586 A	(WHITWORTH) see page 1, line 70	1
X	GB 1294334 A	(A.E.S) see page 2, lines 20 to 34	17
X	GB 938049	(ENGL) see page 2, lines 27 to 65	17
X	GB 754219	(H VOHRER) see page 1, lines 27 to 37 lines 46 to 87	1, 17

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